

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

PRIMARY PARTNER

CFD Research Corporation
Huntsville, Alabama

PROJECT PARTNERS

UNIVERSITIES

Georgia Institute of Technology,
Atlanta, Georgia

University of California,
Berkeley, California

INDUSTRIAL CONSORTIUM

**Siemens Westinghouse
Power Corp.,**
Orlando, Florida

Pratt & Whitney,
East Hartford, Connecticut

General Electric CRD,
Schenectady, New York

Rolls-Royce Allison,
Indianapolis, Indiana

Solar Turbine, Inc.,
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Phoenix, Arizona

Coen Company, Inc.,
Burlingame, California

McDermott Technology Inc.,
Alliance, Ohio

Vapor Power Group,
Niles, Illinois

LARGE EDDY SIMULATION SOFTWARE FOR THE DESIGN OF LOW EMISSION COMBUSTION SYSTEMS FOR VISION 21 PLANTS

Description

Developing a computer simulation that shows how a fuel burns in a combustion chamber will greatly reduce development costs of new, more efficient and cleaner combustor designs. This software will be able to accurately simulate the behavior of burning fuel, as it travels through the combustion chamber, and be able to predict emissions and other performance parameters.

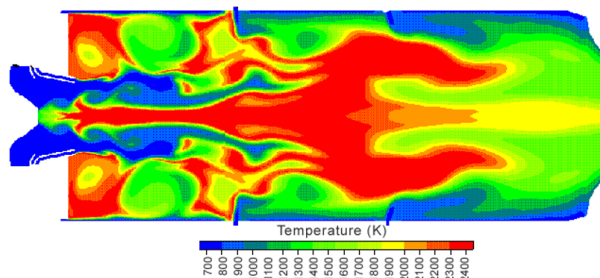
The aim of this project is to develop and validate an advanced computational software tool for the design of low emission combustion systems.

The software will be able to accurately simulate the highly transient nature of gas-fired turbulent combustion and assess innovative concepts needed for Vision 21 plants.

The complex physics of the reacting flow field will be captured using 3-Dimensional, Large Eddy Simulation (LES) methods, in which large scale transient motion is computed by time-accurate numerics, while the small scale motion is modeled using advanced subgrid turbulence and chemistry closures.

Using this approach, LES combustion simulation methods can model many physical aspects that, until now, were impossible to predict using 3D steady-state Reynolds Averaged Navier-Stokes (RANS) analysis. The new simulations will be able to predict very low NO_x emissions, combustion instability (coupling of unsteady heat and acoustics), lean blowout, flashback, autoignition, etc.

LES combustion simulation methods are becoming more and more practical by linking together tens to hundreds of PCs and performing parallel computations with fine grids (millions of cells). Today, such simulations can be performed in a few days or less, while in 5 years, these same calculations could be performed in eight hours or less due to the expected increase of computing power.



Snapshot of 2D LES Calculation Showing the Temperature Distribution of a Liquid-Fueled, High Performance Combustor



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The proposed project will modify and improve subgrid and reduced chemistry models developed by expert university researchers (Dr. Suresh Menon at Georgia Tech and Dr. J. Y. Chen at University of California, Berkeley) and implement them into one of the world's leading combustion software codes, CFD-ACE+. The commercially-available CFD-ACE+ software utilizes unstructured, parallel architecture with accurate spatial and temporal numerics. CFD-ACE+ also features multi-tasking capability so that different physical models can be used in different parts of the computational domain.

To insure that practical, usable software is developed, a consortium of gas turbine and industrial manufacturers will be established. The consortium members who have committed include Siemens-Westinghouse, GE Power Systems, Pratt & Whitney, Rolls Royce-Allison, Honeywell, Solar, Coen, McDermott Technologies Inc., and Vapor Power. They will guide model and code development. Five consortium members will perform beta site testing of the software on their advanced combustion systems. In this way, the software will penetrate the industrial market and be used in the design environment.

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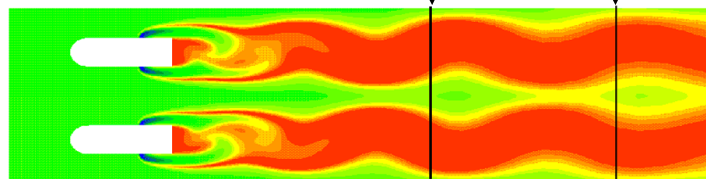
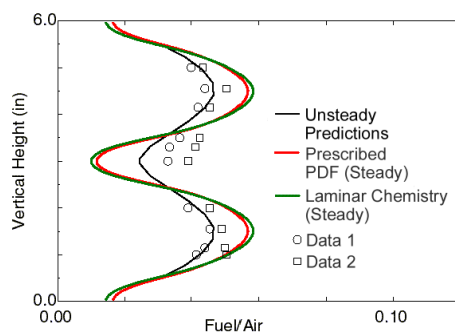
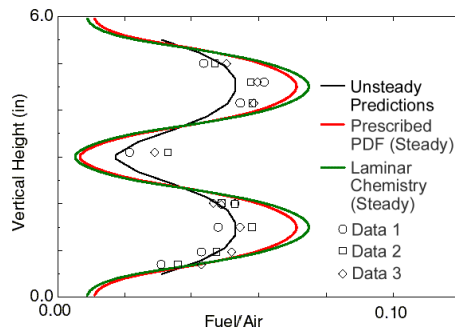
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Comparisons of Measured and Predicted Mean Profiles of Fuel/Air Ratio Using 3D Unsteady RANS Methodology